47TH TURBOMACHINERY & 34TH PUMP SYMPOSIA
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GEORGE R. BROWN CONVENTION CENTER

Case Study on investigation and resolution of Dry Gas Secondary Seal Failure

Girish Kamal

Fairul Azam Bin Salehan

PETRONAS

TEXAS A&M UNIVERSITY

TEES

TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

Presenter/Author bios

Girish Kamal Principal Rotating Equipment Engineer	Girish Kamal is working as Principal Rotating Equipment Engineer with the Centre of Excellence Division of PETRONAS Carigali Sdn. Bhd. in Kuala Lumpur. He has more than 28 years experience in the Oil and Gas Industry in the fields of rotating equipment management for onshore and offshore applications including specifications, design approvals, testing, inspection, commissioning, installation, maintenance and technical services.
Fairul Azam Bin Salehan Senior Rotating Equipment Engineer	Fairul Azam Bin Salehan is working as Senior Rotating Equipment Engineer with PETRONAS Carigali Sdn Bhd. He has more than 12 years experience in maintenance and reliability of Turbomachinery and rotating equipment. He has carried out RCAs for various rotating equipment failures.

Abstract

Dry Gas (DGS) Secondary Seal installed on one of the Flash gas compressor unit at an onshore gas treatment facility failed resulting in equipment downtime and process gas flaring.

During detailed tear down inspection, primary seal was found heavily contaminated with sticky oily substance that reached into the secondary seal leading to contact between the seal faces causing thermal cracks.

This case study will present the problem encountered, root causes analyzed, solutions implemented, results and lessons learnt.

Contents

1. Machine Details
2. Problem Statement
3. Dry Gas Seal System Schematic
4. Chronology of incident
5. Failure Observations & DGS Inspection Results
6. Root Cause Failure Analysis
7. Solutions Implemented
8. Results
9. Lessons Learnt

Machine Details

Flash Gas Compressor (Two stages) Electric Motor Driven

Operating Data:	Stage 1	Stage 2
Suction Pressure:	6.5 bara	20.4 bara
Suction Temp.:	55.5 deg C	49.9 deg C
Discharge Pressure:	21.28 bara	62.8 bara
Discharge Temp.:	139.4 deg C	142.5 deg C
Inlet Volume:	2740 m3/hr	781 m3/hr
Mol. Wt.:	29 kg/kmol	
Speed:	14853 rpm	
Train Power:	2010 KW	

Unit was installed & commissioned in 2012 but running in intermittent operation.

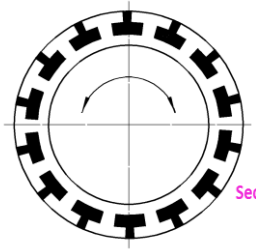
Problem Statement

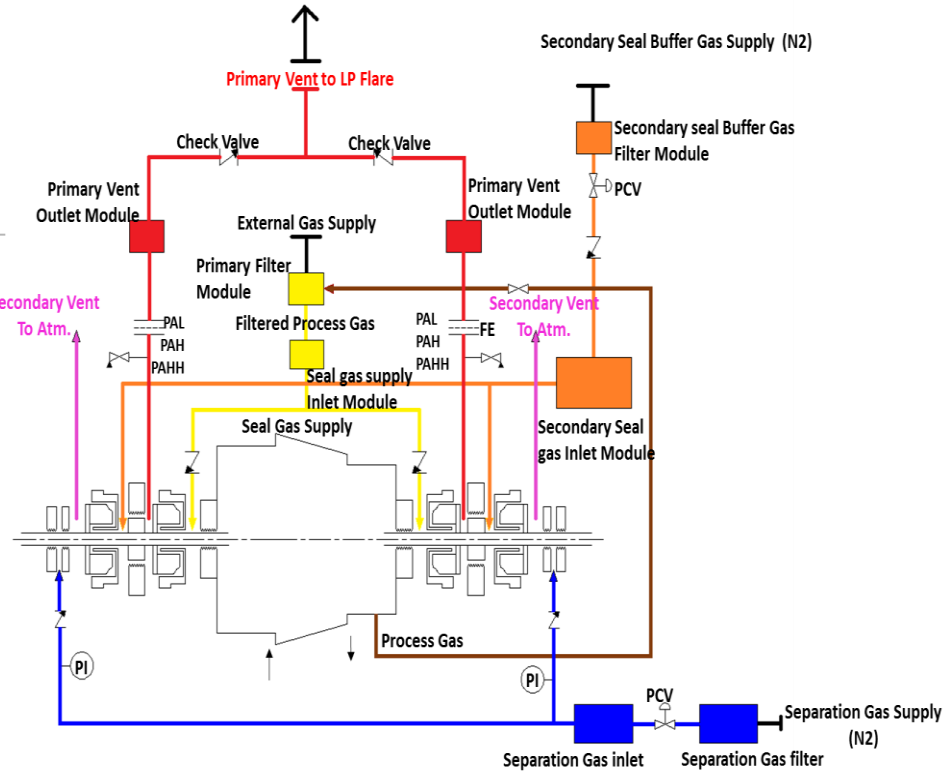
- Flash Gas Compressor unit fitted with Tandem Dry Gas seal with intermediate labyrinth.
- Both the Primary & Secondary high vent pressures are monitored with alarm as well as shutdown safeguards provided therein.
- High vent pressure alarm appeared on the Secondary Seal (non drive end) during operation in Jan-2014.
- Eventually the compressor unit tripped on Secondary seal NDE high high vent pressure limit after approx. 50 minutes.
- **Dry Gas Seal failure.**

Dry Gas Seal System Schematic/Details

DGS Details:

- Tandem arrangement with intermediate labyrinth.
- Bi Directional T-Groove Patterns.
- Seal Gas Heater to maintain seal gas supply temperature.
- Seal gas supply with 3um duplex coalescing filter assembly (Beta Ratio >/= 200).
- Plant nitrogen being used as buffer gas for intermediate seal as well as separation gas for bearing housing.
- Buffer/Separation Nitrogen gas filtration with 3um duplex filters (Beta Ratio >/= 200).





Chronology of Incident

28/01/14 (01:02AM)

Secondary seal NDE high vent pressure alarm appeared

28/01/14 (01:51AM)

Secondary seal NDE vent pressure exceeded the high-high limit and compressor tripped

28/01/14 (02:28AM)

Attempted to start the unit but failed due to secondary NDE pressure high-high shutdown

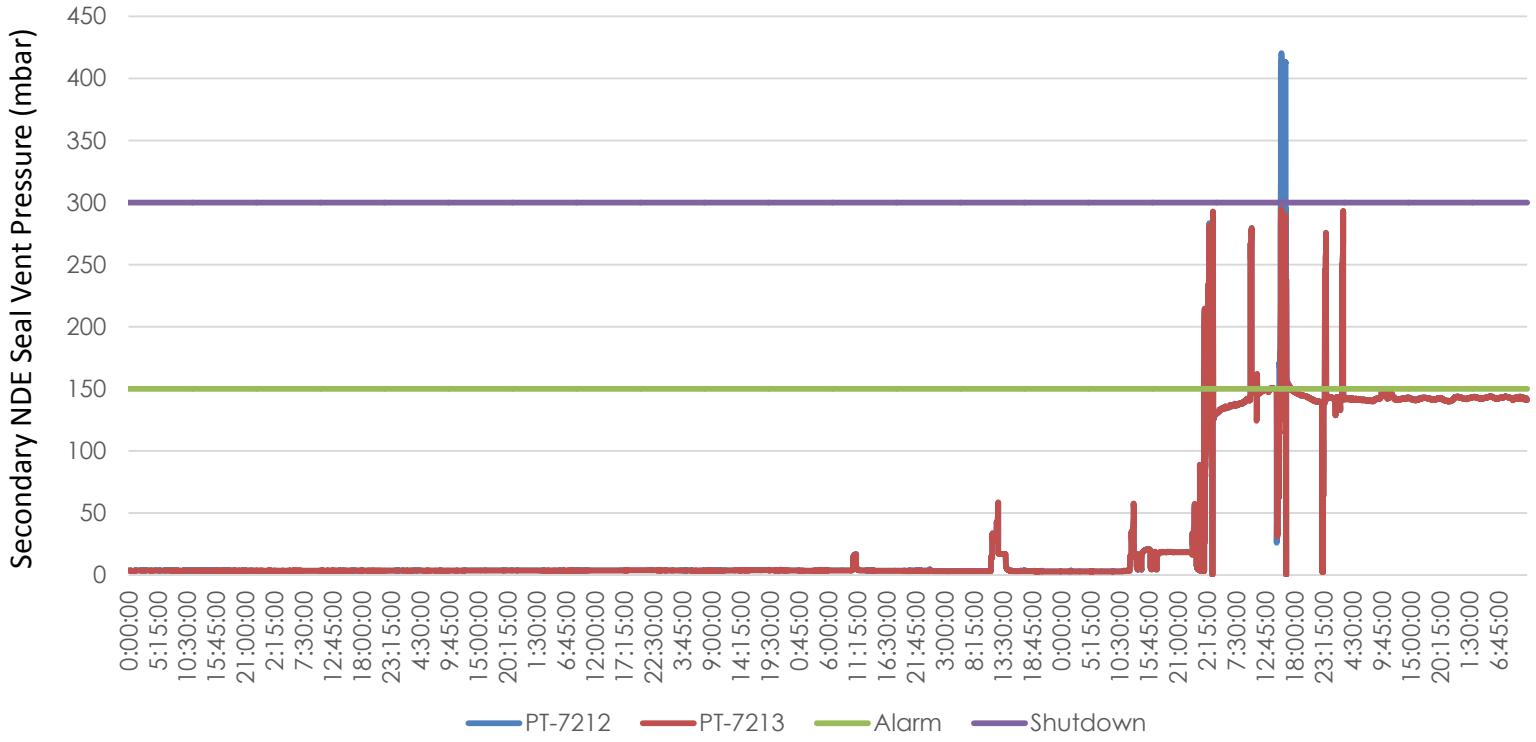
29/01/14 (09:00AM)

Inst. Checks conducted on the Secondary seal NDE Vent pressure transmitters confirmed genuine reading

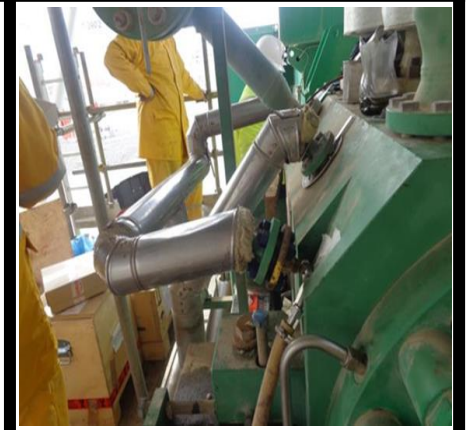
29/01/14 (01:00PM)

Verified historical data trending from DCS and confirmed DGS failure

Historical Trending of NDE Seal Pressure Monitoring



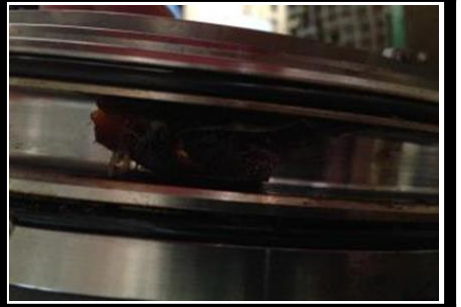
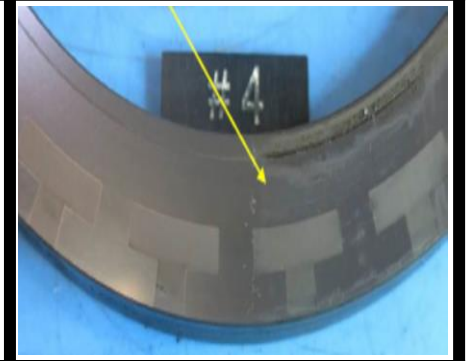
Failure Observations

1. Carbon dirt / soot inside the Seal Gas Filter Casing.			
2.Dirty Seal Gas Coalescing Filter. 3.Contaminated Seal Gas Supply piping.			

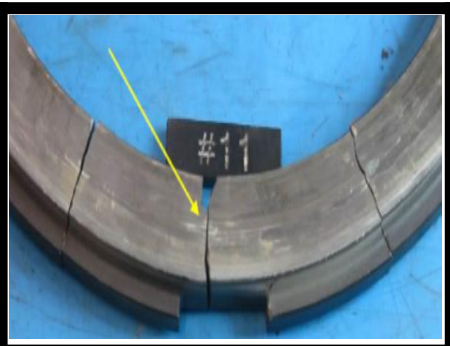
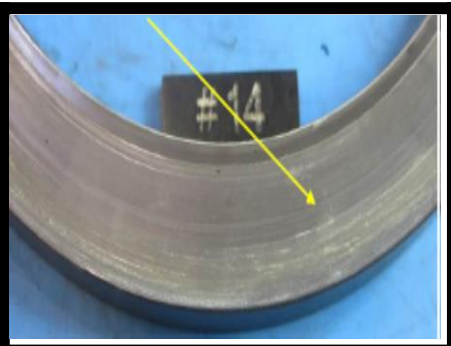
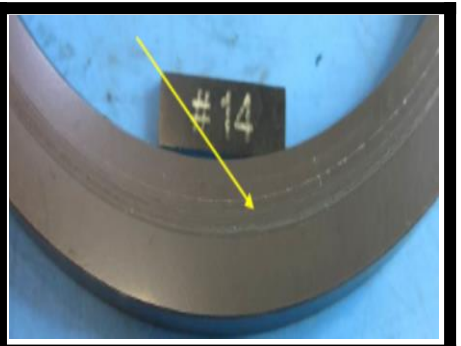
Failure Observations

4.Foreign material inside the seal gas heater.			
5.Very dirty Primary seal. 6.Contaminated DGS casing.			

Failure Observations & DGS tear down Inspection Results

7.Condensate deposits inside the seal casing and outside the DGS cartridge.			
8. Seal Ring (#1) and Mating Ring (#4) from primary seal - Contaminated with rust like substance and liquid and contact traces on the sealing surface.			

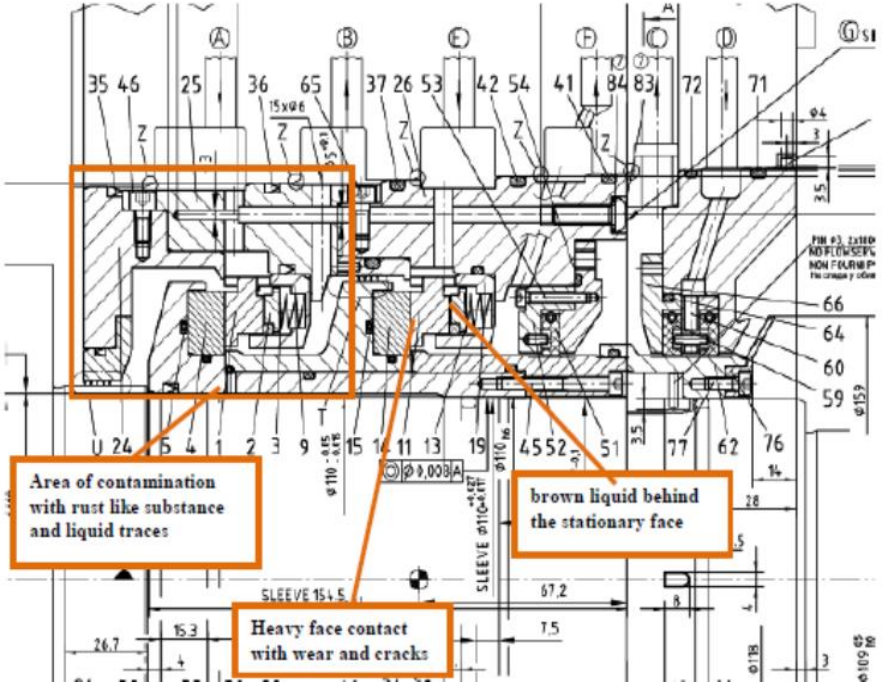
DGS tear down Inspection Results

9. Seal Ring (#11) and Mating Ring (#44) from secondary seal Heavy contract traces on the sealing surface and seal face broken in several parts			
10. Seal element (#2) from primary sealing and seal element (#12) from secondary sealing - Heavily contaminated with rust like substance and liquid. Pitting marks on the surface.			

Root Cause Failure Analysis

Direct Causes:

- Heavy face contact with wear on the rotating face sealing surface of the Secondary Seal.
- Presence of liquid dusty substance in the secondary seal gap that caused the face contact.
- Heavy contamination with rust like particles and traces of liquid in the Primary Seal/Process side.



Root Cause Failure Analysis

Indirect Causes:

- Poor seal gas supply quality due to inadequate filtration.
- Dirty seal gas supply lines and seal gas heater (improper flushing).
- Dirty and un-cleaned process gas coming in contact with the seal mating faces.
- Hydrate and liquid formation (condensation) on seal faces while seal gas expanding and loss of dew point margin.

Solutions Implemented

1. Seal Gas conditioning to prevent liquid condensation.
2. Maintaining effective heat tracing for seal gas supply piping.
3. Cleaning of the seal gas/buffer gas filter housing.
4. Cleaning/flushing/blowing of the seal gas supply piping and heater using N2.
5. Replacement of seal gas coalescing filters and N2 buffer/separation gas filters.
6. Weekly Equipment Basic Care (EBC) program for the seal gas supply/vent lines & coalescing filters.
7. SAP Mplan re-scheduling to 8K PM (from 16K PM) for the seal gas filters replacement & Filter DP transmitter tapping line/needle valve inspection.
8. Ensuring no occurrence of liquid carry over during pigging activity.

Results

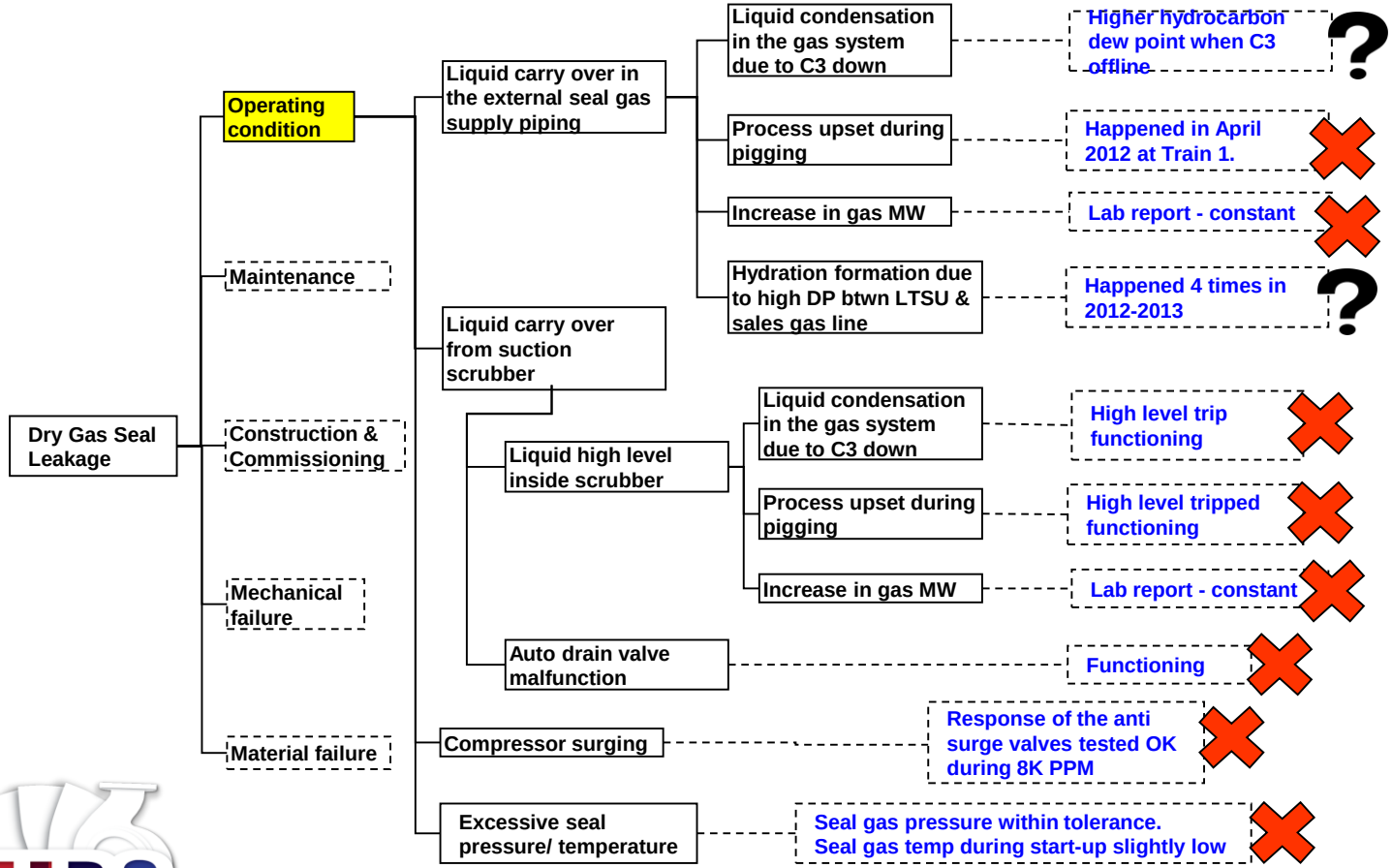
- ✓ DGS & Compressor system uptime and reliability improvement with no more Dry Gas Seal failures post solutions implementation.
- ✓ MTBF > 04 years and still counting….

Lessons Learnt

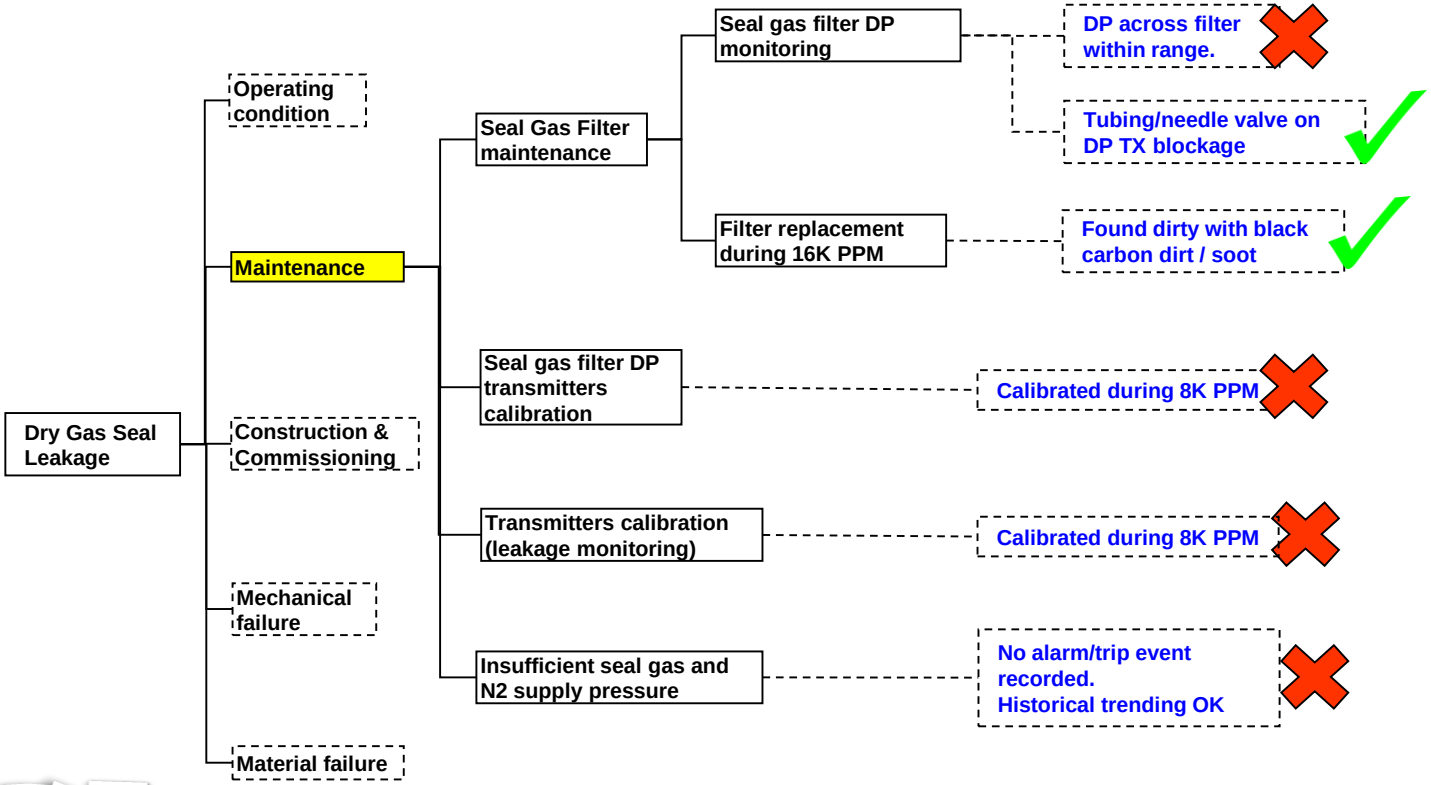
- Sufficient seal gas dew point margin throughout the entire seal gas system to prevent hydrate and liquid formation on seal faces.
- Adequate QA/QC checks during pre-commissioning activities especially during seal gas piping cleaning and flushing.
- Design, Operation & Maintenance considerations for the entire seal gas system to ensure reliable DGS operation.
- Dry Gas Seal health monitoring including tracking and trending of Primary as well as Secondary seal vent pressures/flows.
- Eliminate process interruption (e.g. during pigging) to prevent contaminants going into the sealing system.

Back-Up Slides

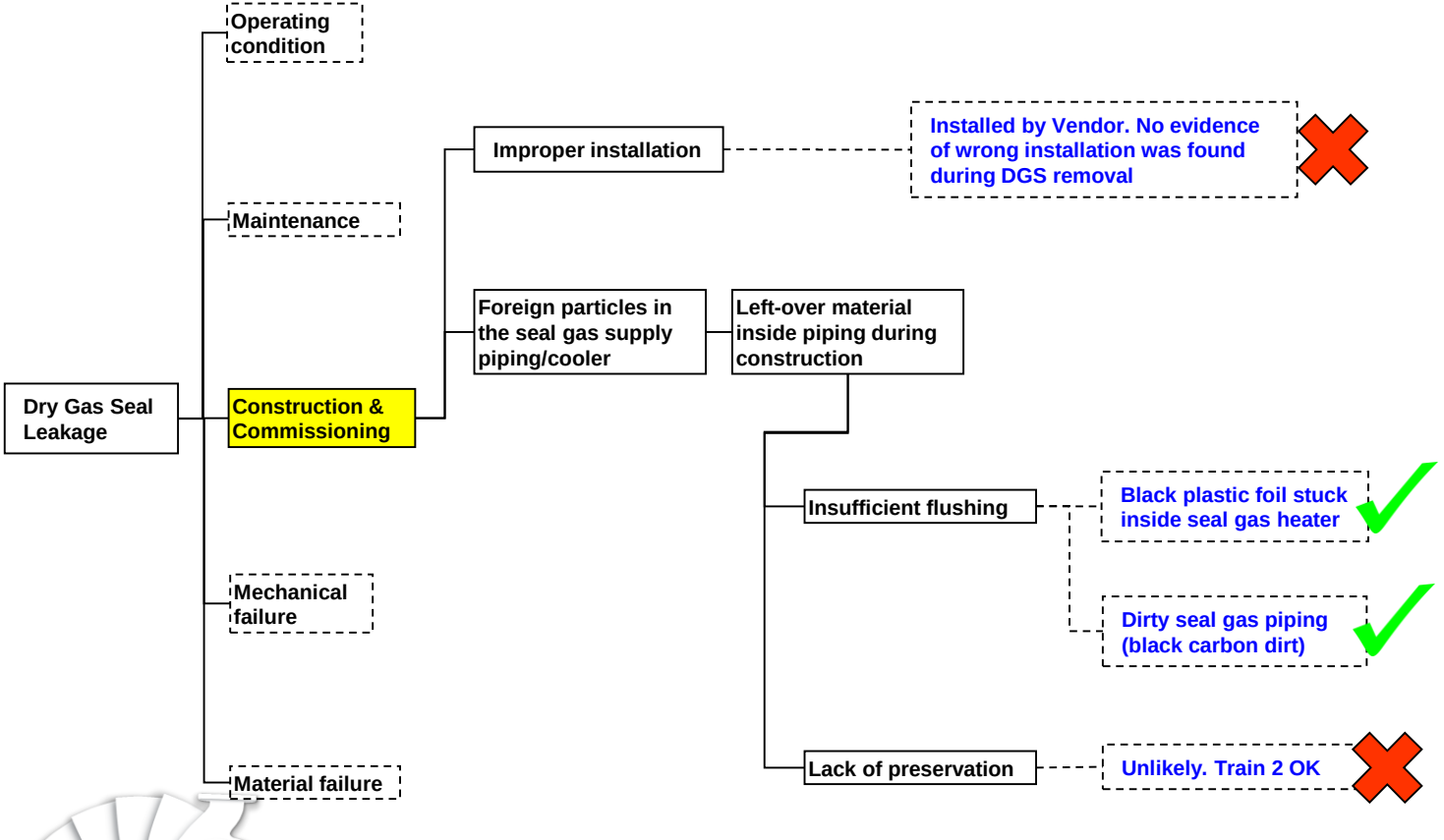
Root Cause Failure Analysis



Root Cause Failure Analysis



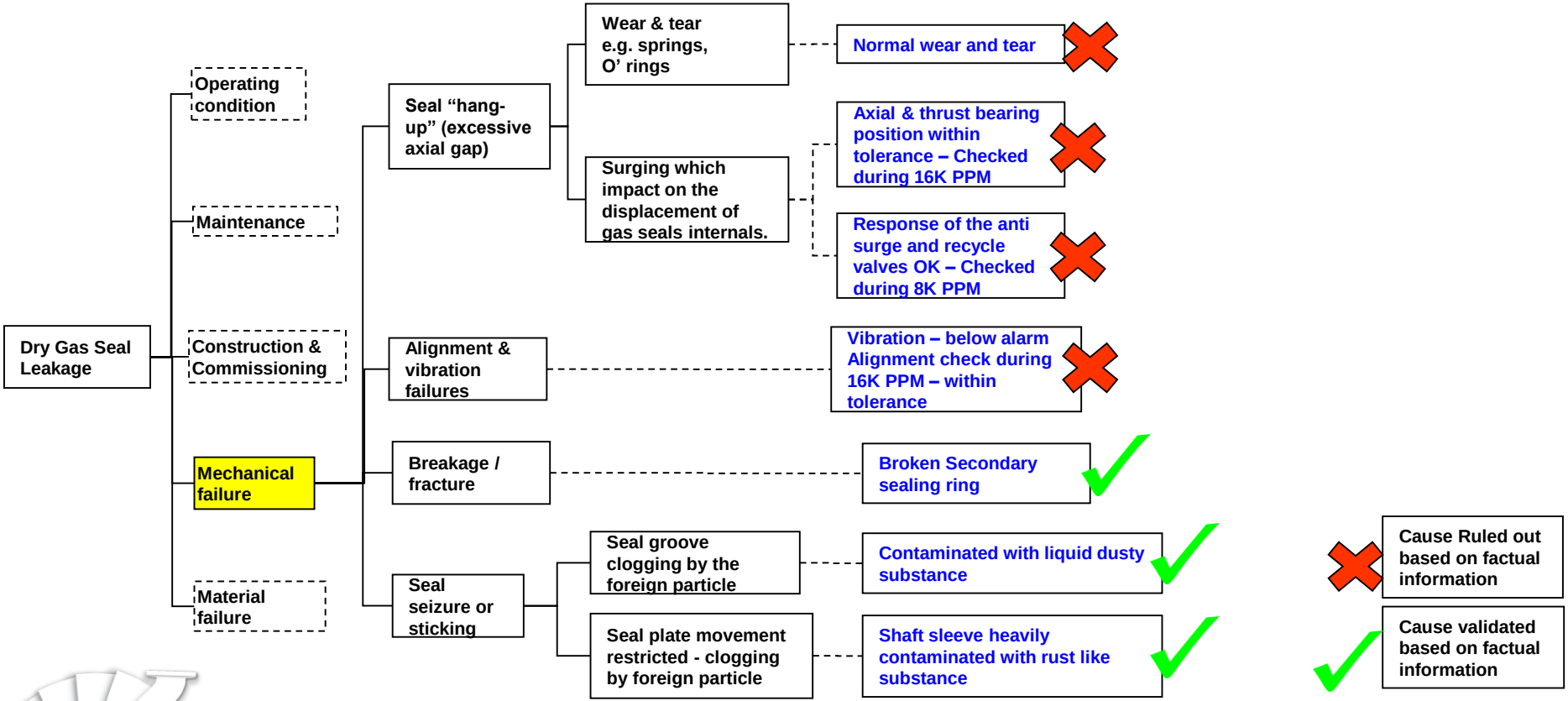
Root Cause Failure Analysis



Cause Ruled out based on factual information

Cause validated based on factual information

Root Cause Failure Analysis



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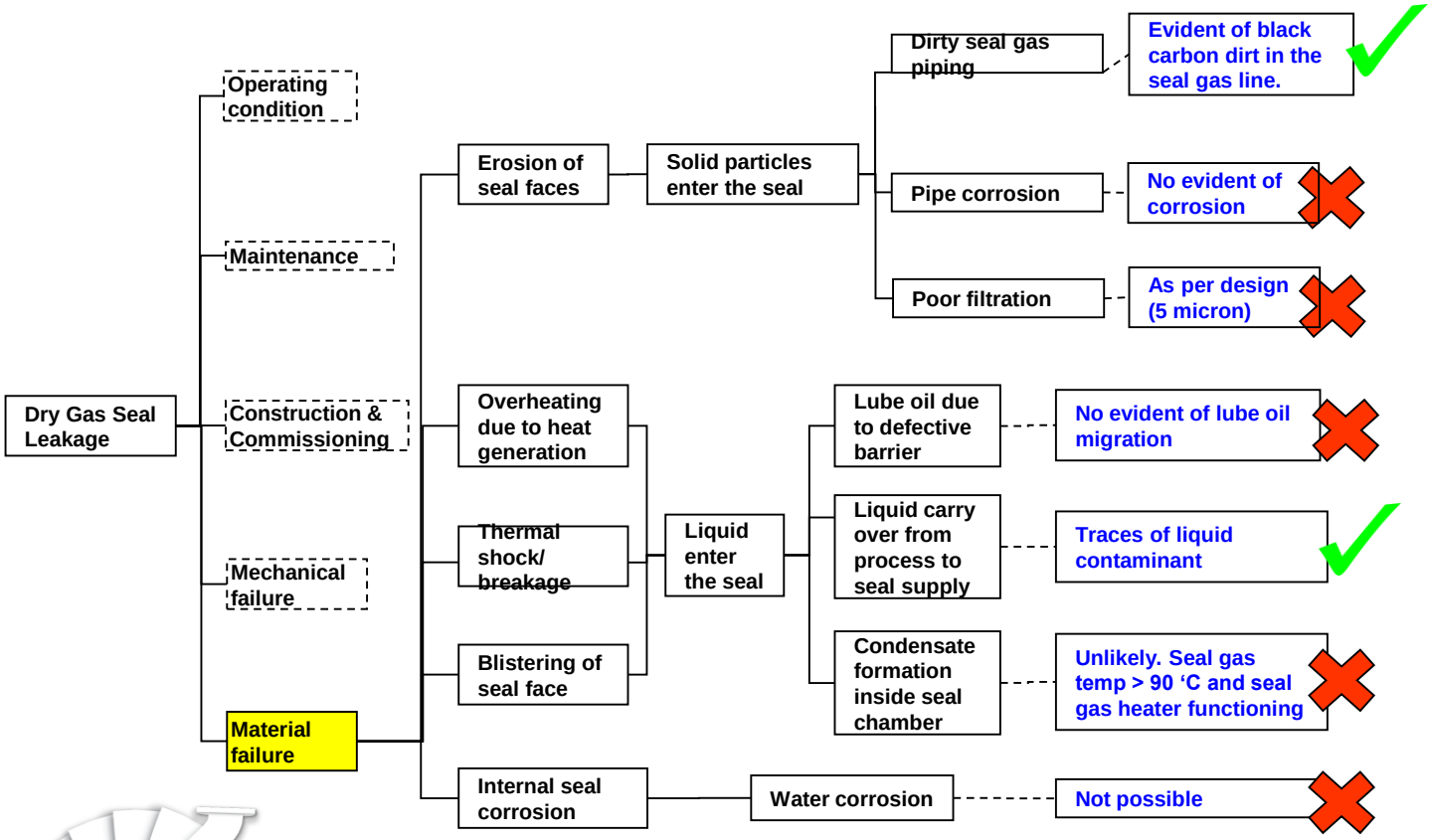

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